Demographic connectivity of sardine in the Bay of Biscay and Iberian coast region

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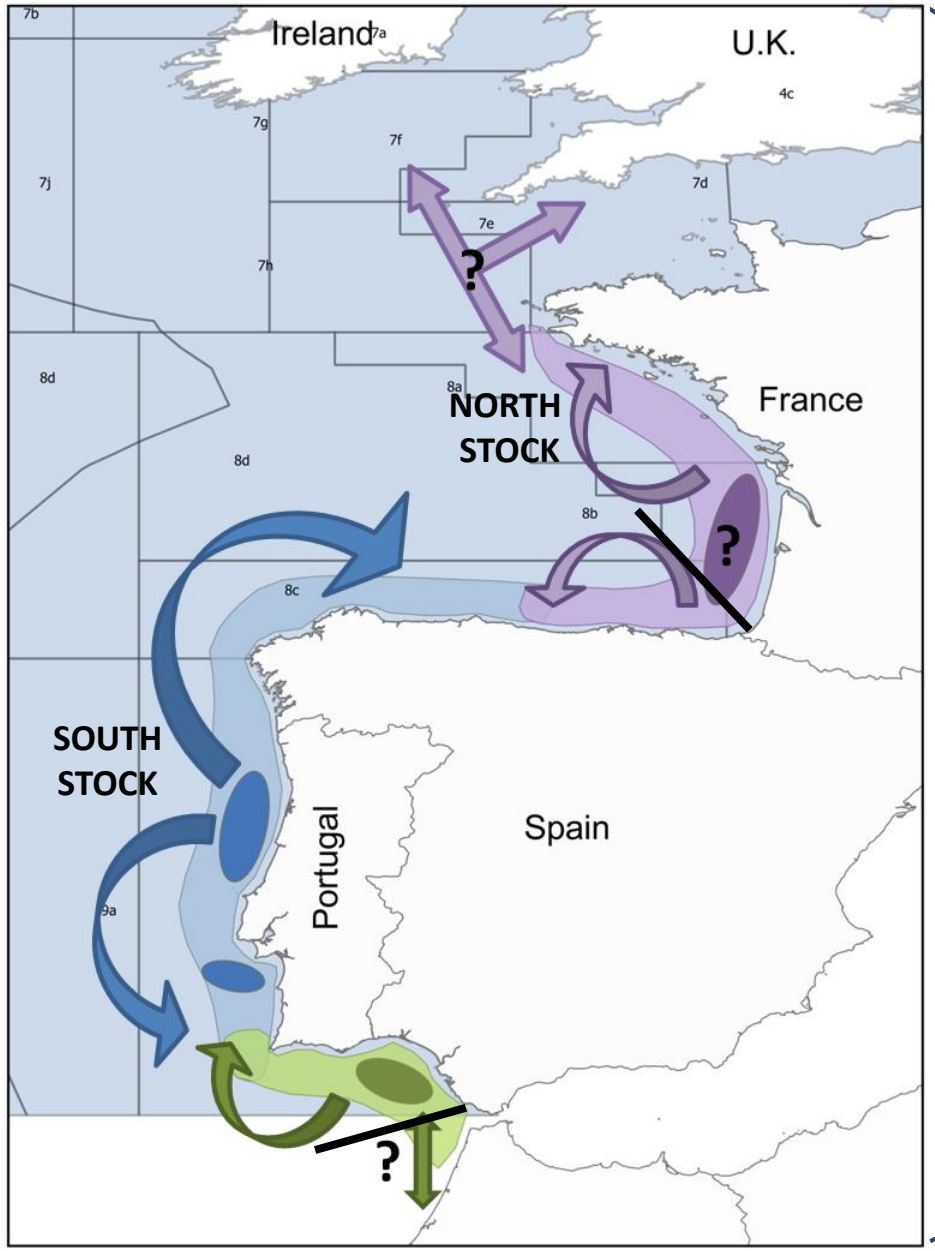
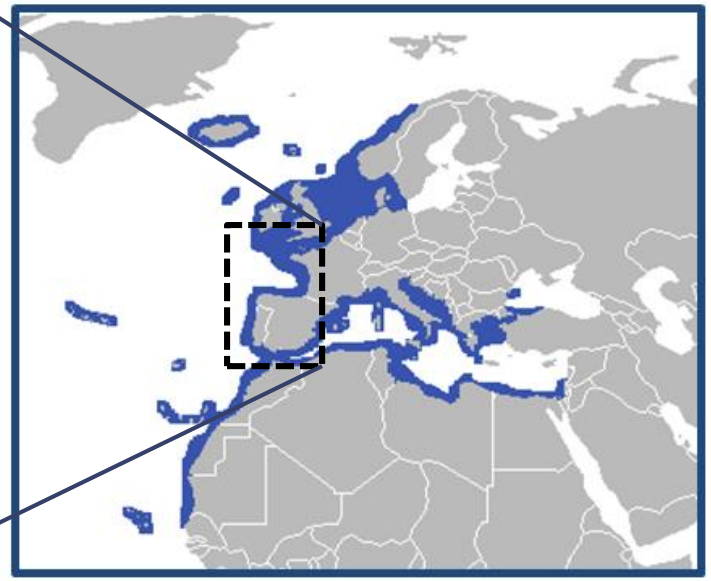
Conceptual model of population structure and connectivity



RECRUITMENT HOTSPOTS

FLOW DIRECTION

DISTRIBUTION AREA



Project SARDYN

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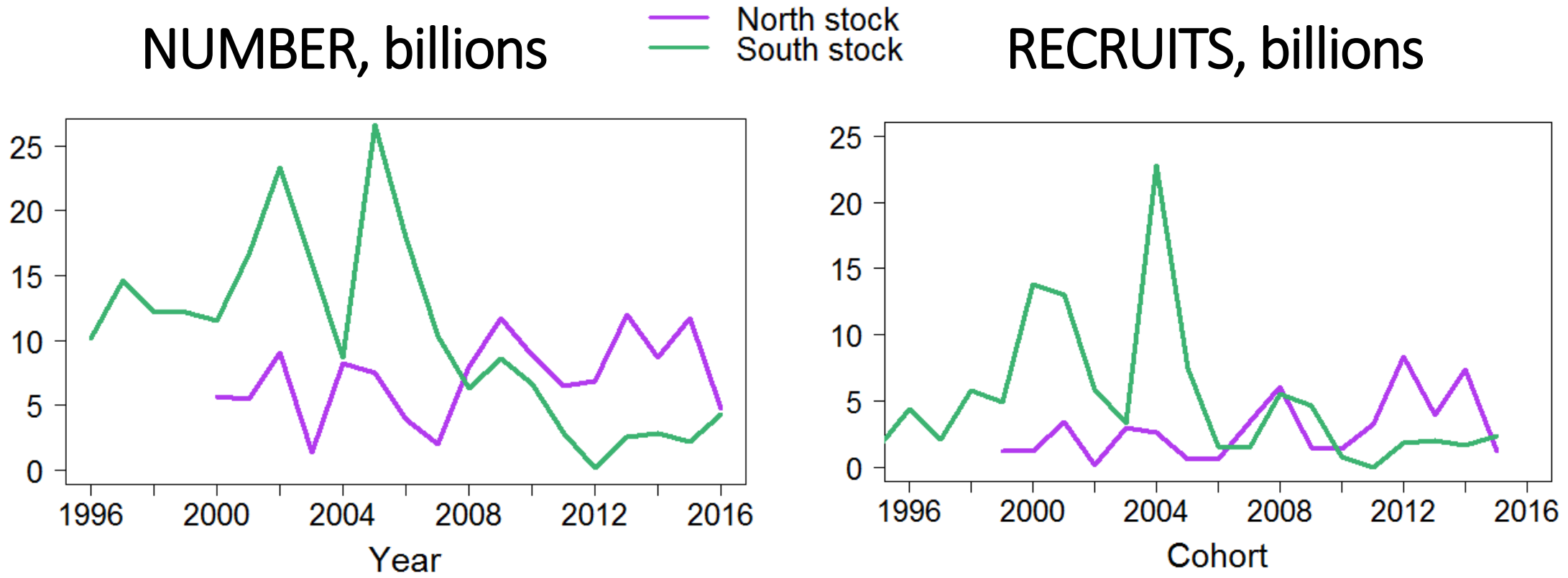
Questions relevant for fisheries management

- What is the origin of sardine appearing in non-recruitment areas, such as North Spain and South Portugal ?
- How strong is the dependency between areas ?
- What drives connectivity between areas ?
- May one stock help to recover the other stock ?
- Are there actually two stocks ?

Development of the stocks



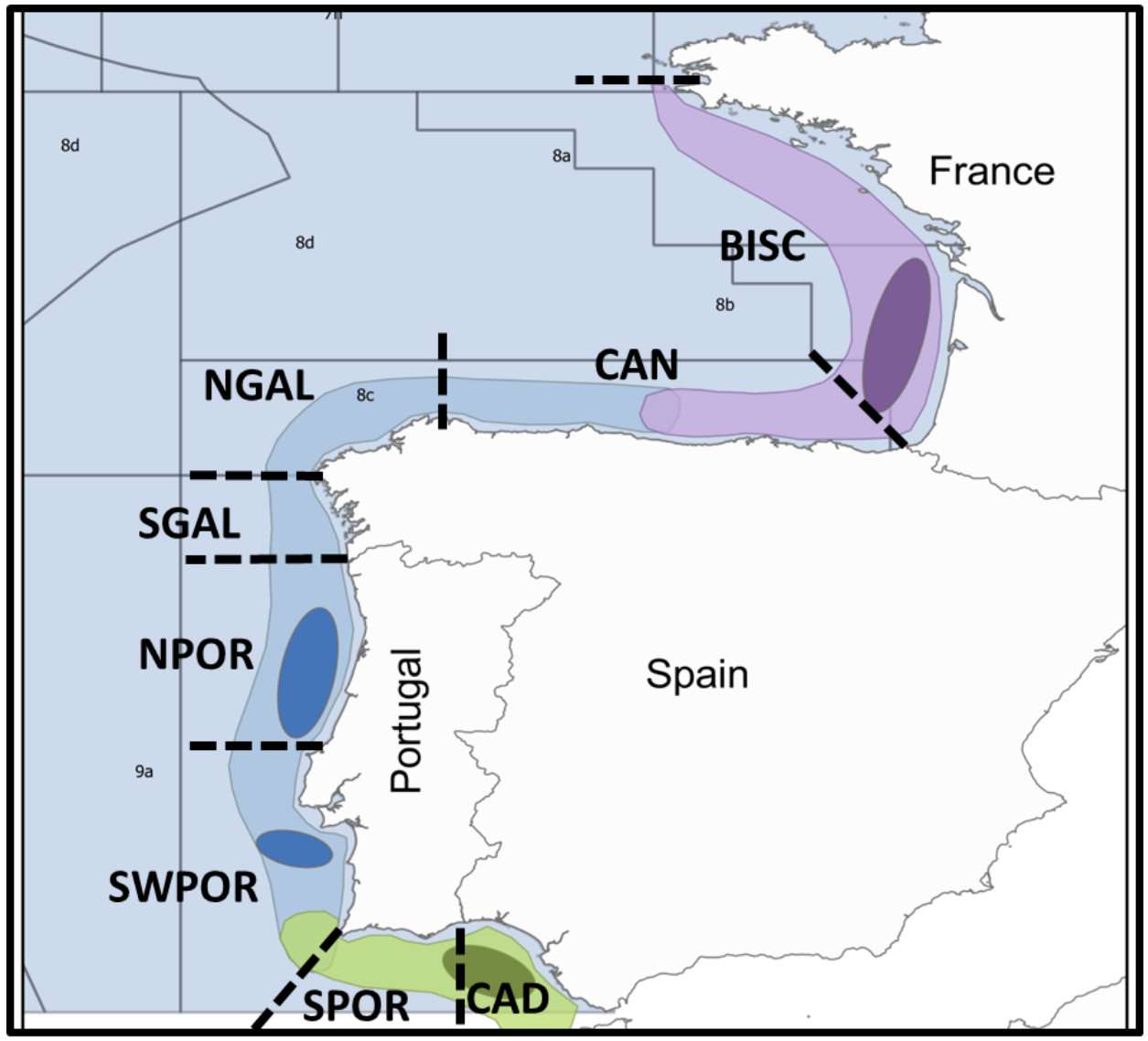
Objectives

- Investigate the dispersal of cohorts across the region
- Explore effects of cohort strength, density and environmental conditions on dispersal

Data

- Abundance-at-age in spring acoustic surveys
- Catch biomass and catch-at-age
- Satellite-derived SST and Chl *a*

2000 – 2016



DATA DISAGGREGATED IN 8 AREAS:

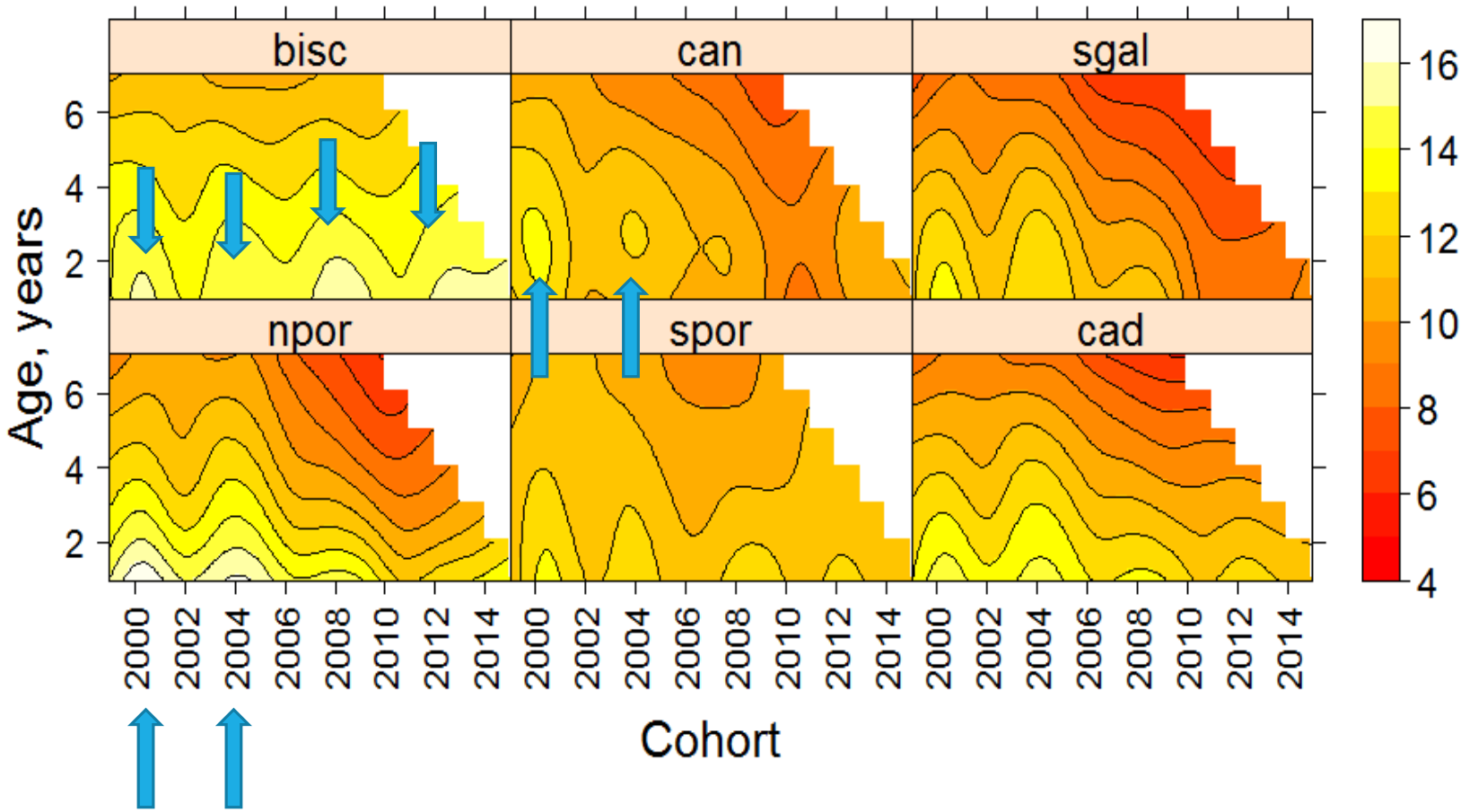
BISC - Bay of Biscay
CAN – Cantabrian Sea
NGAL – North Galicia
SGAL – South Galicia
NPOR – North Portugal
SWPOR – Southwest Portugal
SPOR – South Portugal
CAD – Gulf of Cadiz

Results

1. Cohort dispersal between areas
2. Inflow and outflow areas, flow directions
3. Relationship between outflow, cohort strength, density and Chl *a* in spring and summer

1. Cohort dispersal

Recent strong cohorts born in BISC did not flow to northern Spain or south of it



NPOR≈SWPOR

CAN≈NGAL

Two-part GAM fitted to survey abundance data

Age, area and cohort as predictor variables

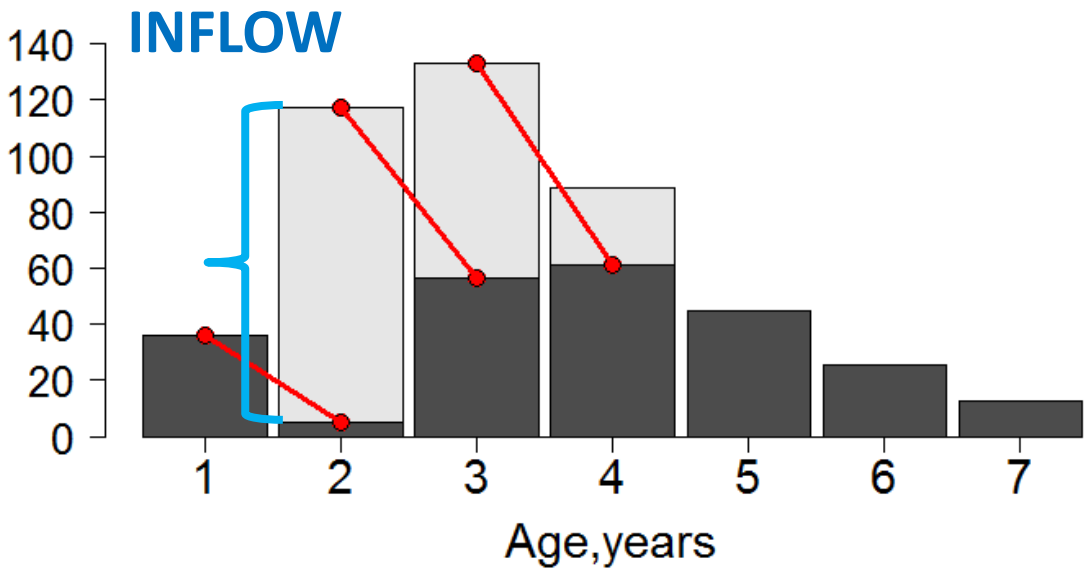
Presence model explained 46.5% deviance

Count model explained 74.8% deviance

Flow ?

ONE COHORT

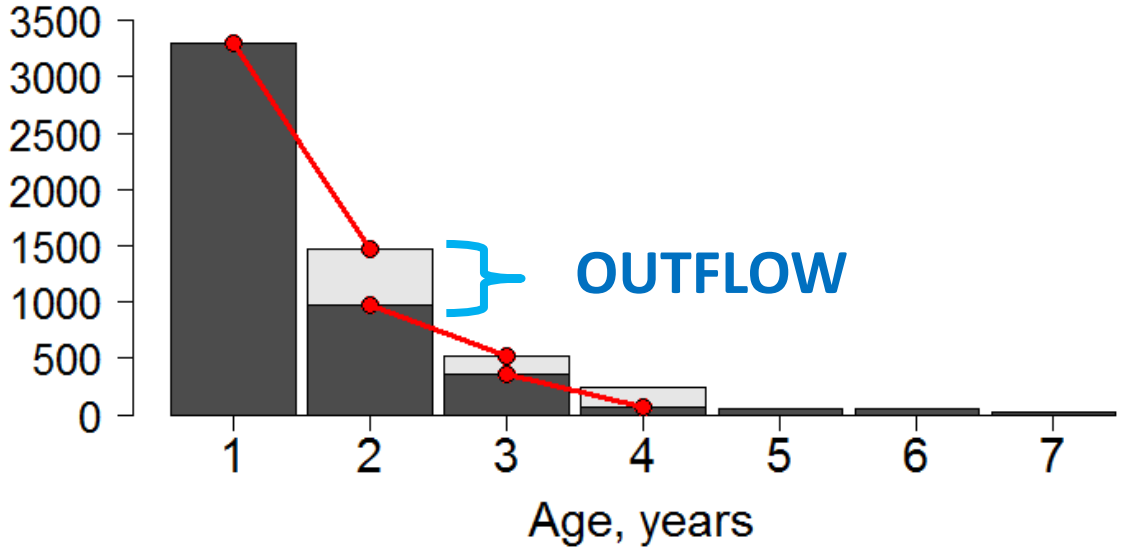
Typical of Cantabrian Sea



Total bars: survey abundance
Red lines: natural + fishing mortality
Grey part of bars: fish that entry the area

INFLOW: index positive

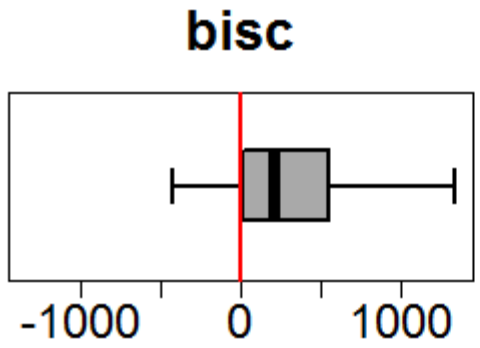
Typical of North Portugal

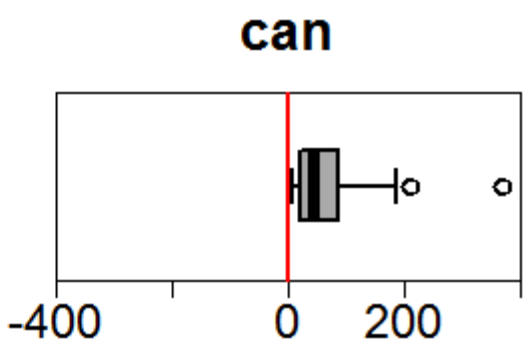


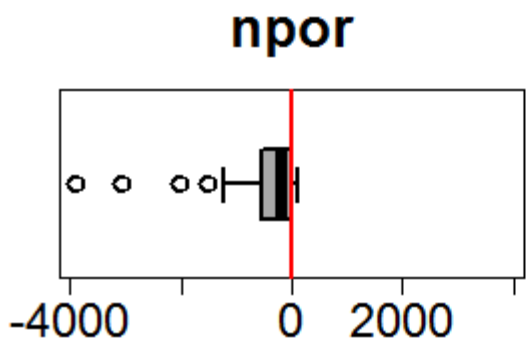
Black part of bars: survey abundance
Red lines: natural + fishing mortality
Grey part of bars: fish that exit the area

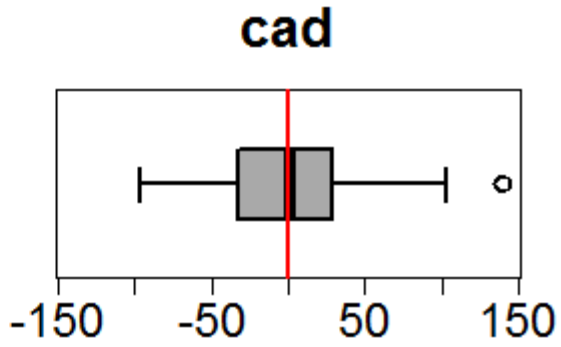
OUTFLOW: index negative

Inflow and outflow areas









BISC~SGAL~SPOR – mostly inflow

CAN~NGAL – only inflow

NPOR~SWPOR – mostly outflow

CAD – inflow and outflow

Relative flow index

	bisc	can	ngal	sgal	npor	swpor	spor	cad
Age 1-2	32	82	208	114	-75	-25	38	17
Age 2-3	1	63	177	66	-17	-5	31	-11

Relative inflow index

$$\frac{\text{No. individuals that flow into the area}}{\text{No. individuals born locally}}$$

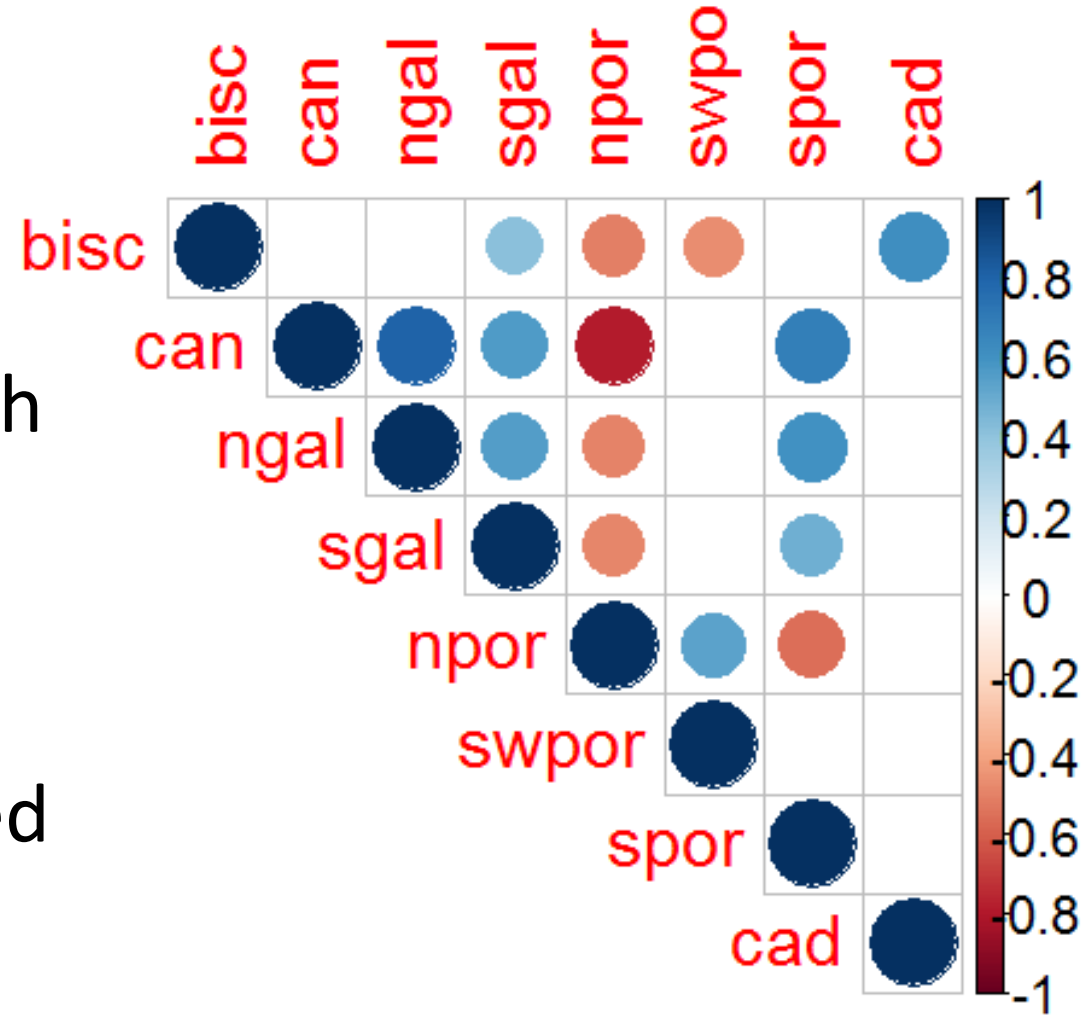
Relative outflow index

$$\frac{\text{No. individuals that flow out of the area}}{\text{No. individuals stay locally}}$$

Flow directions

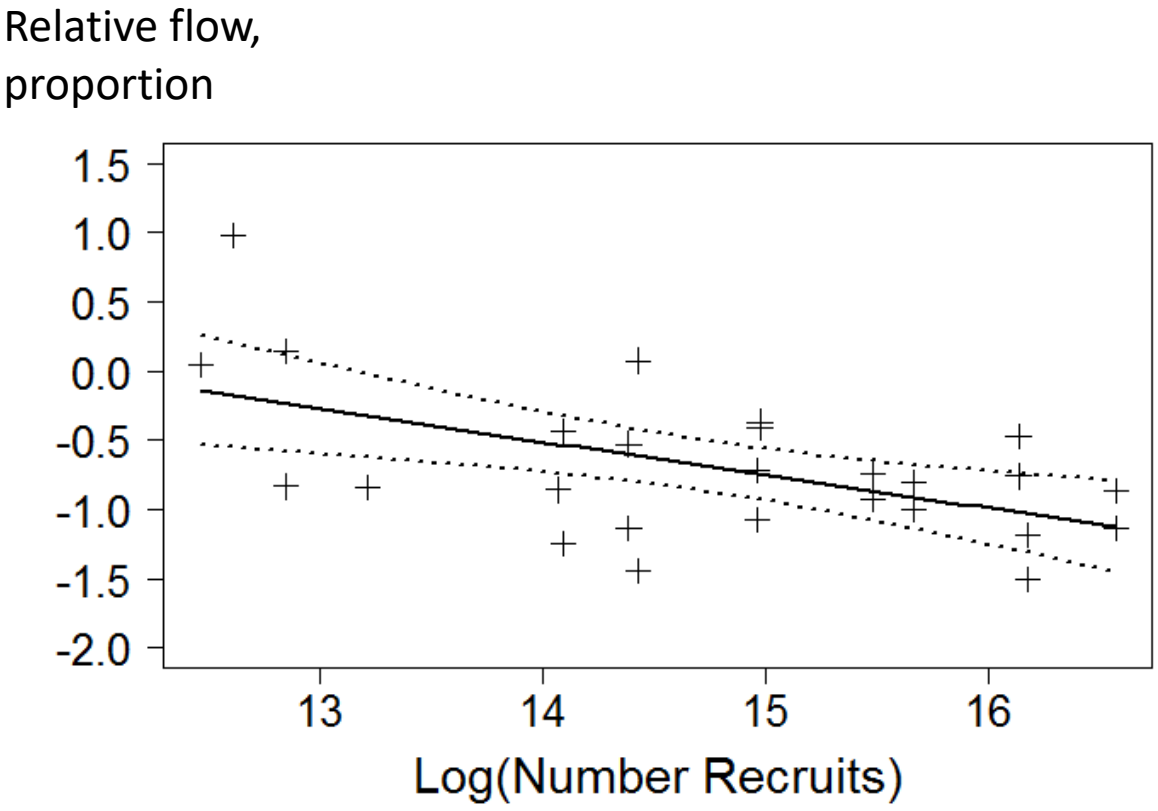
Individuals flow from North Portugal to all other areas except the Gulf of Cadiz.

Gulf of Cadiz not connected with other areas.



Significant Spearman correlations between relative flow indices at the 0.01 level

Relationship between outflow, cohort strength, density and Chl a (spring, summer)



Outflow from North Portugal significantly correlated with cohort strength (r^2=0.26, p<0.01).

Outflow from Southwest unrelated to all tested variables.

Brief summary

- All areas, apart from CAD, appear to be connected to west Portugal by cohort dispersal
- CAN and NGAL depend on dispersal from west Portugal
- SPOR depends on a mixture of local recruitment and inflow from west Portugal
- Flow of sardine from west Portugal to BISC contradicts evidence they are self-sustained populations
- Connectivity influenced by recruitment strength; environmental conditions affecting recruitment will also impact dispersal
- North stock is not contributing to avoid the decrease of the South stock

Final remarks

- Sensitivity of the flow index to various assumptions (survey catchability, natural mortality) needs to be tested

- Combine our approach with otolith microchemistry, growth pattern analysis, IBM

- Integrate regional dynamics and connectivity into assessment and fisheries management

Thank you very much
for your attention !

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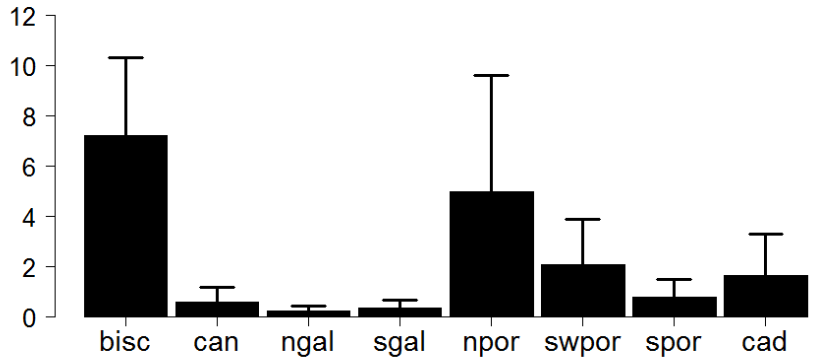
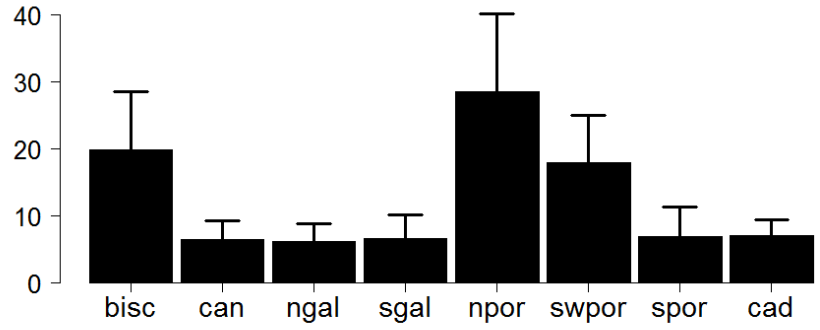
Matthiew Doray (IFREMER) provided data on sardine positive area in PELGAS surveys.

extra

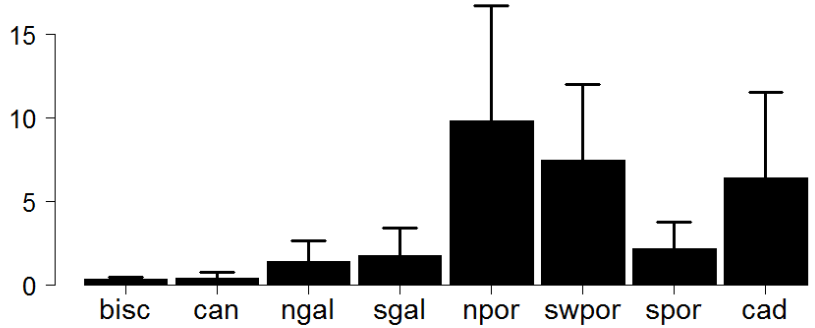
ABUNDANCE, billion indiv.



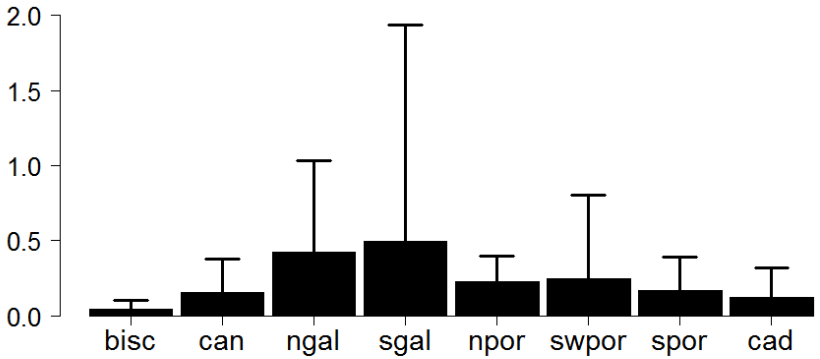
CATCH, thousand tons



DENSITY, thousand indiv./nm^2

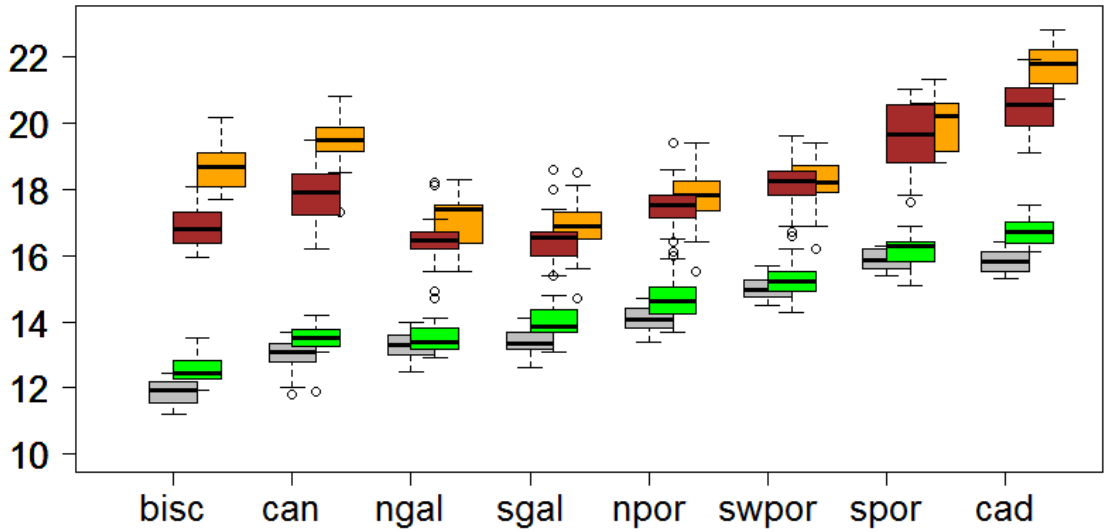


HARVEST RATE, proportion

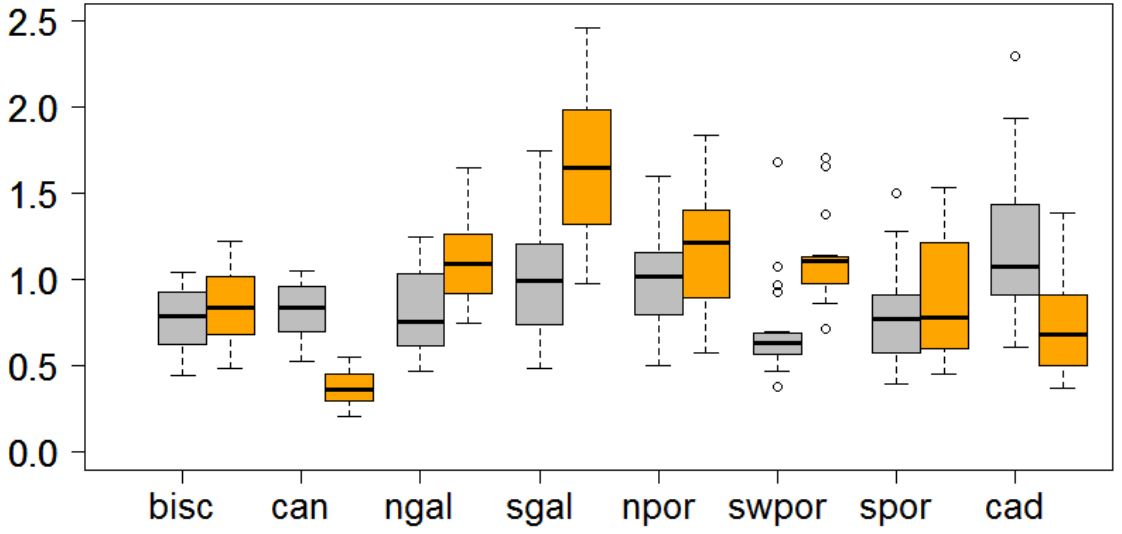


WINTER			SPRING			SUMMER			FALL		
Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov

SST, ° C



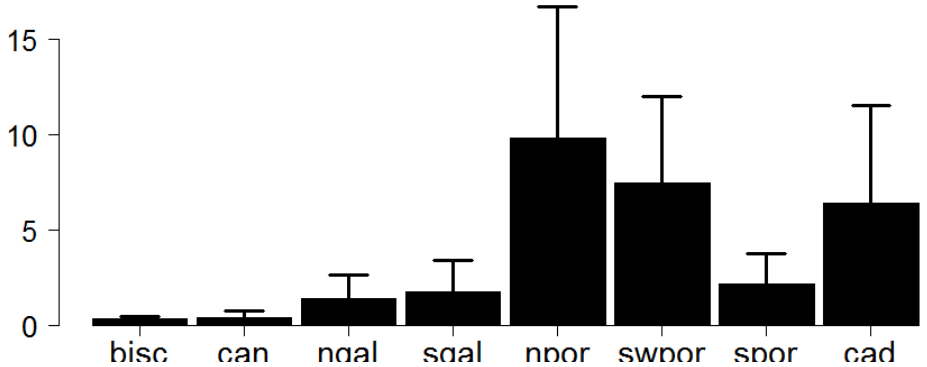
Chl *a*, mg m^{-3}

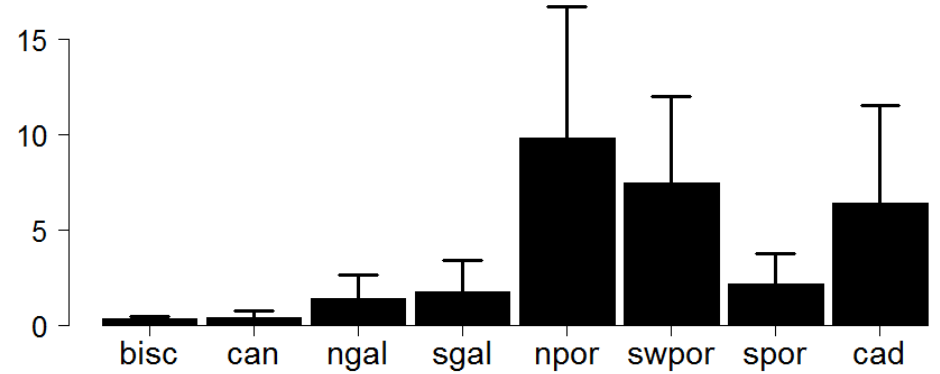


- North to south increase in SST in winter/spring
- Western Iberia the coldest in summer/fall

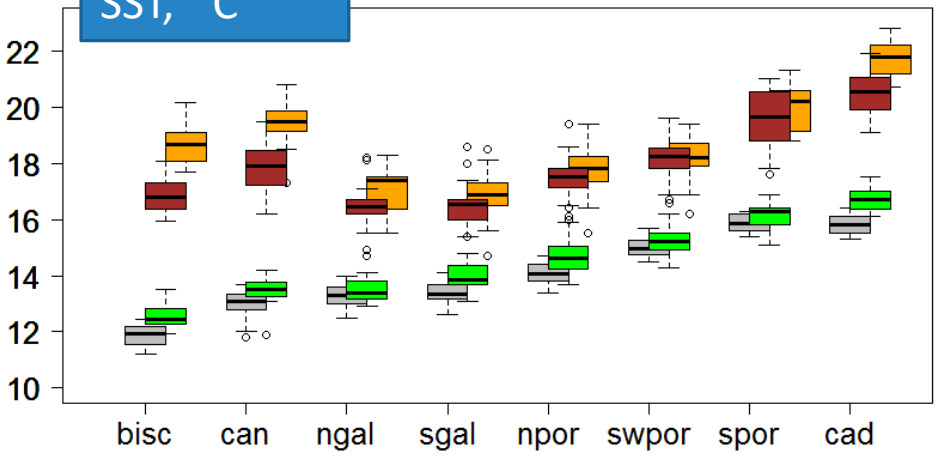
- North-western Iberia the most productive area all year round
- Cantabrian Sea generally less productive

DENSITY, thousand indiv./nm^2

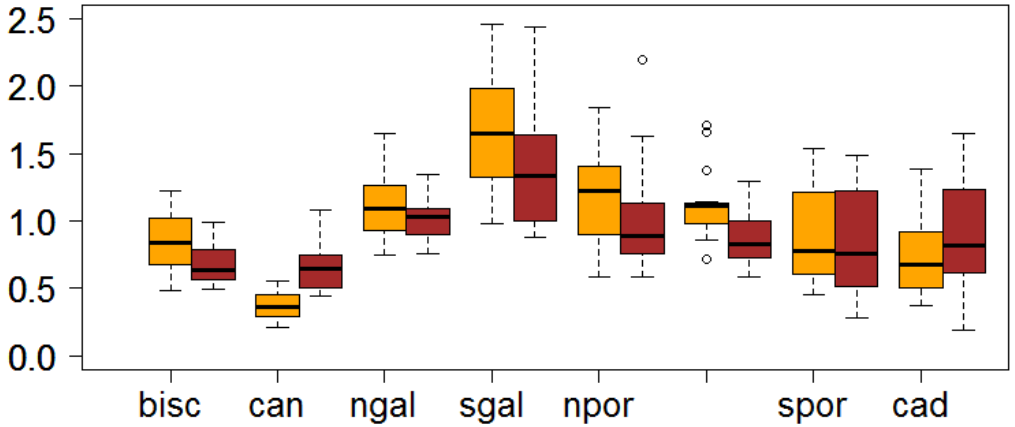




SST, ° C



Chl *a*, mg m^{-3}



- Higher density in areas with mild winter temperature and low summer temperatures/high productivity
- Density is higher in area with higher productivity all year round